Pilot Study: Swimming for Children with Cerebral Palsy.

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BENEFITS OF SWIMMING FOR CHILDREN WITH CEREBRAL PALSY: A PILOT STUDY

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Abstract The aim of this study was to investigate the effects of a swimming program on body function, activity and Quality of Life (QOL), in children diagnosed with Cerebral Palsy. Seven children (female/male: 4/3; Median 10.2 years old; Gross Motor Function Classification Scale I to III) participated in a 6-week swimming intervention using a case series design. Outcome measures were, for body function level: handgrip strength; for activity level: unimanual speed performance, walking capacity, gross motor function and adjustment and function in the water; and QOL. There was no drop-out during the intervention. Mental adjustment in the water and swimming skills improved by 29% ($p < 0.05$) after the intervention. This effect remained at follow-up ($p < 0.05$). Subdimension D (standing) of the Gross Motor Function Measurement-88 improved significantly (3%). All other activity measurements showed trends toward improvement. QOL improved in five out of seven subdimensions of one questionnaire. To conclude, this pilot study including a small number of participants showed improvements in adjustment and function in the water and positive trends for activity level and QOL after a 6-week swimming program. Future research on a larger population could be worthwhile.

Key words: Swimming, aquatic therapy, motor skills

INTRODUCTION

Cerebral Palsy (CP) 'describes a group of disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances occurring in the developing foetal or infant brain' [4]. Primary problems in CP are abnormal muscle tone, impairment of balance and coordination, decreased muscle strength and loss of selective motor control. Children with CP also experience secondary musculoskeletal problems such as muscle contractures, skeletal deformities and pain [4, 30]. One specific problem at body function level which has gained attention in recent years is upper limb strength and its impact on performance of functional skills [26]. Deficits in these body functions, as defined in the International Classification of Functioning, Disability and Health model (ICF) [40] contribute to problems at the level of activity, e.g. gross motor function [28] and walking [8], and at participation level [5, 40]. All of these factors impact the overall Quality of Life (QOL) [7].

To date, numerous therapeutic interventions have been used to minimize the development of secondary problems, improve muscle strength and mobility, obtain functional motor skills and encourage functional independence [30]. Exercise in water has been found to be an excellent medium for attaining maximal exercise levels in people with or without disabilities. One physical aspect of water, buoyancy, frees a submerged body from the downward pull of gravity, resulting in decreased joint loading [3, 23]. Weight relief and ease of movement allow safe movement exploration, strength and functional activity training [11, 25]. Another physical property of water, hydrostatic pressure, which is the force exerted by water on an immersed object, is directly proportional to the depth of immersion. This can provide enhanced tactile input [23]. Viscosity, cohesion, adhesion and surface tension can provide a graded progression of resistive exercises [23]. Finally, the turbulence of fluid molecules moving past one another, a fluid dynamic property, can be used to challenge a person's balance or assist movement through water [15]. These characteristics may allow children with CP to exercise in water with more freedom than on land. In water, they may achieve as much as able-bodied peers, which may have a major psychological impact affecting the QOL.

Swimming can also be used as a recreational activity [3], perhaps countering the low activity level seen in children with CP [6]. In fact, learning to swim is particularly important for a child with a lifelong

developmental disability as the aquatic environment may offer a unique opportunity to engage in self-directed, meaningful exercise, fitness, and recreation. Although swimming and other aquatic exercises are often included as part of the physical therapy program for children with CP, three systematic reviews [16, 19, 20] concluded that there is lack of research on the effect of an aquatic intervention in children with CP.

Walking capacity has been investigated in various aquatic case studies, few case series designs and one controlled trial. Getz et al [18] reported improvements in self-selected velocity of the 10-meter walk test for both the aquatic and land-based training group in 3- to 6-year-old children with spastic diplegia (Gross Motor Function Classification Scale (GMFCS) I–III). Similar results were reported in the case series design by Thorpe et al [36] for the 3-minute walk test. Additionally, Ballaz et al [2] showed an improvement in gait efficiency after a 10-week swimming program in 12 adolescents with CP. No other study (with $n > 2$) investigated the effect of swimming in children with CP on walking capacity.

Different studies addressed gross motor function measured by the Gross Motor Function Measurement (GMFM). Four studies [2, 12, 24, 36] reported significant improvements after an aquatic intervention. In the study by Dimitrijević et al [12] the swimming group increased significantly (4.4%), compared to the control group (0.6%) after a 6-week swimming program in children with CP (GMFCS level I to V). The total score and the subdimension for walking of the GMFM improved significantly in seven children with CP after a 6-week swimming program [24]. This subdimension for walking of the GMFM improved in three more case series designs, for adolescents [2, 10] and children [36] with CP. In contrast, Getz et al [18] reported no significant changes in the GMFM total score (0.8 point decrease) in a group of six 3–6-year-olds with spastic diplegia (GMFCS level I to III) after a 4-month program including 32 30-min sessions of “adapted” aquatics compared to a small increase in the land-based training group. However, they did find a 5.9 pt. improvement in the subdimensions for standing and walking of the GMFM for the aquatic group compared to a 0.8 pt. improvement for the land-based group. Manual performance (paper and pencil manipulation) also improved after an aquatic intervention in a group of children with severe CP [27].

To our knowledge, only limited research has been performed on the effect of a swimming program, designed to improve safety and functional independence in water, in children with CP on walking capacity, gross motor function and upper limb performance. No such study has investigated the effects on upper limb strength and QOL in children with CP.

The goal here, therefore, was to investigate the feasibility and effect of a 6-week twice-weekly aquatic intervention program on upper limb strength, upper limb performance, gross motor function, walking capacity, water adjustment skills, and QOL in children with CP.

MATERIALS AND METHODS

PARTICIPANTS

Children diagnosed with CP were recruited for the study. All children met the following criteria: (1) aged 5–13 years; (2) ability to understand instructions; (3) no medical contra-indications; (4) no botulinum toxin type A injections or surgery in the preceding three months; (5) written parental approval.

An invitation letter was distributed through local paediatric physiotherapists, the regional ‘CP reference centre’ and a special school. Eight children agreed to participate and completed the baseline measurements. The parents and children gave informed consent prior to data collection and the study was conducted in accordance with the Helsinki Declaration of 1975, as revised in 2000 [41].

PROCEDURE

This study employed a case series design, consisting of a baseline (one week), intervention (six weeks) and follow-up (three weeks) period (see Figure 1). Outcome measures were administered at three or four time points: once or twice at baseline, i.e. before the intervention was initiated, and at the end of the 6-week intervention. The follow-up assessment was conducted three weeks after intervention.

The two repeated measurements during the baseline period were used to control for changes anticipated with testing and other environmental factors. All tests were performed by the main investigator.

Baseline			**Post intervention**	**Follow-up**
Week 1	Week 0	Intervention 6 wks	Week 6	Week 9
All outcome measurements	Hand grip Jebsen-Taylor 10-MWT		All outcome measurements	All outcome measurements

Figure 1. Study design

Note: The measurement of the hand grip strength, the Jebsen-Taylor Hand Function test and the 10-MWT were the three tests measured once more, before the first swimming session (week 0).

ASSESSMENTS

Descriptive measures such as age, gender, body weight, height, dominant hand (the hand preferred for performing activities of daily living), cause of CP, gestational age, type of brain lesion, type of CP, amount of PT, swimming experience, use of orthotic devices, other sport or leisure activities, other medical problems, type of education and date of last botulinum toxin type A infiltration or surgery were recorded for all participants. The Manual Ability Classification System level (MACS), was used to classify the children's use of hands in daily life. The Gross Motor Function Classification Scale scores were used to determine the children's present abilities and limitations in gross motor function. Both classification systems were found to be valid [14, 29].

BODY FUNCTION LEVEL

Hand grip strength was measured using the Jamar Hydraulic Hand Dynamometer in a sitting position as suggested by the American Society of Hand Therapists [9]. The mean score (kg) of three successive trials for each hand was recorded. Test-retest reliability for this measurement in children was high [38].

ACTIVITY LEVEL

The Jebsen-Taylor test of hand function served as a general timed measure of unimanual performance. This test consisted of seven tasks: writing; turning cards; picking up small objects; simulated eating; stacking checkers; and moving light (250 g) and heavy (500 g) cans. The writing task was excluded, since young participants were not able to write the required sentence. Each subtest was quantified as the time (s) it took to accomplish the task with each hand separately. If a participant was unable to complete a task or if task completion exceeded two minutes, he or she was assigned a score of 120 s on that subtest. The test-retest reliability was proven to be high [35].

The Gross Motor Function Measure–88 (GMFM-88) is a standardized observational instrument developed to measure change in gross motor function over time. The test consisted of 88 items categorized in five dimensions (Dimension A: lying and rolling, Dimension B: sitting, Dimension C: crawling and kneeling, Dimension D: standing and Dimension E: walking, running and jumping). The test was conducted as described in the GMFM-88 manual [33]. A percentage score as compared to maximum was calculated for each dimension and for the total score of the five dimensions. The measure was found to be reliable [33].

To measure 10-meter walking speed (10-MWT), participants were instructed to walk at a comfortable pace over a 14 m distance of which the time was taken over the middle 10 m. Participants ambulated barefoot and without aids. The mean speed of three attempts was taken. This test was found to be reliable and valid [32 ,35].

The swimmer's level of adjustment and function in water was assessed using the 27-item Water Orientation Test Alyn 2 (WOTA 2). The evaluation was based on the 10-point Halliwick concept, subdivided into several skills. The scale consisted of two subdimensions, Mental Adjustment (MA) and Skills, Balance & Movement (SBM), containing 13 and 14 items respectively. Both the swimmer and instructor were in the water at the time of testing. In addition to verbal instruction, the instructor demonstrated the required task and each item was attempted up to three times. A 4-point ordinal scale (0-3) was used to score each skill based on the level of performance and independence. A maximum of 81 points could be achieved and all absolute scores were converted to a percentage. The scale was found to be reliable and valid for children with disabilities [37].

QUALITY OF LIFE

The CP Quality of Life Questionnaire for Children is a condition-specific QOL questionnaire evaluating the influence of interventions on QOL in children with CP. Social well-being and acceptance, participation and physical health, functioning, emotional well-being, pain and impact of disability, access to services (Parent version) and family health (Parent version) are measured. The Parent-Proxy version (for parents of children aged 5–15 years), comprising 66 items, was distributed to all parents. After explanation, the parent completed the questionnaire at home, or while their child was being tested. The same parent completed the Parent-Proxy version at each assessment (CPQOL – parent). The Dutch translation of the questionnaire was found to be reliable and valid [34].

The Assessment of Life Habits Short Form questionnaire aims to determine how a person accomplishes a group of daily living activities, characteristic of a young person in his or her environment. These include regular activities (e.g. eating meals, communication, etc.) and social roles (e.g. going to school, engaging in social relationships, participation in recreational activities) that allow young people to function and achieve their potential in the society. The questionnaire, designed for 5- to 13-year-old children, consisted of 64 questions subdivided in 12 categories (Nutrition, Communication, Housing, Recreation, etc.). The Dutch version was completed by the same parent at each measurement point (LH – parent). Validity and reliability of this assessment was determined [27].

INTERVENTION

The participants were enrolled in the swimming program for six weeks with two 1-hour sessions per week. The main objective of the swimming program was to improve safety and functional independence in water together with learning different swimming strokes. The main investigator ran the swimming program with the assistance of three additional instructors, with one or two participants per instructor. A maximum of three children were in the pool at the same time (25 m by 13.33 m, 125 cm to 135 cm deep in the 13 m shallow area with water temperature 27.7 °C).

The aquatic program consisted of 10 min of light warm-up in the water (forward and backward walking, jumping, blowing bubbles), 40 min of exercising swimming techniques (aquatic breathing; safety techniques such as changing positions from prone to standing; prone and back gliding from the wall; prone and back floating; rotations; breaststroke, backstroke or front crawl techniques; diving to the pool bottom) and 10 min of play (ball games, chasing games). The content of the therapy was individualised; depending on the preferred swimming technique, the respective child performed more breaststroke than front crawl or vice versa, or focused more on arm than on leg movements or vice versa. A diary was kept of each individual swimming session to follow-up the goals and progression and to plan each new session.

STATISTICAL ANALYSIS

Descriptive statistics were calculated for all outcome measures. Friedman's Two-way Analysis of Variance by ranks was used to analyse data. Data was used of all participants who completed the baseline and post-intervention measurement and at least half of the swimming intervention (minimum 6 sessions). For the outcomes where the second baseline measurement was available, only the second value was used in the analyses. Missing data were replaced by the last measured value. If the test revealed to be significant, the Wilcoxon signed-rank test was used to determine the time moments within which the difference was significant. An α-level of 0.05 was used in the statistical analyses. Effect sizes (ES) were calculated by dividing the mean difference by the pooled standard deviation. Cohen's interpretation of the effect sizes was used, whereby scores of 0.2 were considered small, scores of 0.5 were considered moderate and scores of 0.8 were considered large [31]. SPSS version 19.0 was used. For one child no questionnaires were completed (parents were no Dutch speakers) and therefore the child was excluded from the statistical analysis of the QOL questionnaires.

RESULTS

One child dropped out before the start of the intervention due to a behavioural problem. All other participants completed the intervention period (n = 7). One child did not perform the follow-up measurement because of incompatibility with the parent's work schedules.

BASELINE

Descriptive data for the participants that completed the intervention are provided in Table 1. The median age of the sample was 10.2 years (Inter Quartile Range (IQR) 2.3). The sample consisted of various types of CP as indicated in Table 1 (one child with a spastic diplegia, one child with spastic quadriplegia, two children with spastic hemiplegia, one child with dyskinetic CP, one child with ataxia and one child was unclassifiable). The GMFCS levels ranged from I to III, and the MACS levels ranged from I to IV. The median GMFM-88 result at baseline was 89.9% (IQR 15.6). At baseline the WOTA 2 results ranged from 0% to 79% with a median of 48.2% as seen in Figure 2 and Table 2. The two baseline measurements (week -1 and week 0) for hand grip strength, the Jebsen-Taylor test and the 10-MWT did not differ significantly.

INTERVENTION

All children completed the minimum of six sessions to be included in the analysis. A median of 12 sessions was reached with an IQR of 1.5. Four children attended all 12 sessions. Reasons for not attending were 'Laryngitis Subglottica', menstruation, or being out of the country. A median of 42.5 min (IQR 7.5) per session was achieved.

OUTCOMES

The subtest Employment of the LH – parent questionnaire was not included in the total score, as 15 out of 18 values were missing.

Table 1. Descriptive data of participants at baseline

Baseline descriptor		Sample (*n* = 7)	IQR*
Gender	Male/Female	3/4	
Age (years)		10.2	2.3
Weight (kg)	29.4	30	12
Height (m)		1.44	0.17
CP Type	Spastic Bilateral	2	
	Spastic Unilateral	2	
	Dyskinetic	1	
	Ataxic	1	
	Non-classifiable	1	
Cause	Prematurity with bleeding	2	
	Cytomegalovirus	1	
	Asphyxia	3	
	Unknown	1	
GMFCS	I	4	
	II	1	
	III	2	
	IV, V	0	
MACS	I	3	
	II	0	
	III	2	
	IV	2	
ASD		2	
PT (min/week)	0	1	
	60	3	
	120	1	
	150-180	2	
Swimming experience		5	
Botulinum toxin type A last 6 months		1	
Education			
Regular education		2	
Special education Motor disorder		4	
Special education Learning disorder		1	

Note: Table indicates number of participants, except median results for age, height and weight;
*IQR: Inter Quartile Range calculated by Excel 2007;
GMFCS: Gross Motor Function Classification Scale; MACS: Manual Ability Classification Scale;
ASD: Autism Spectrum Disorder; PT: Physical Therapy.

All children improved significantly (individual results are shown in Table 2) for both the Mental Adjustment subdimension ($\chi 2 = 13.00$, $p = 0.002$) and the Skills, Balance & Movement subdimension ($\chi 2 = 10.38$, $p = 0.006$) as well as the total score ($\chi 2 = 13.00$, $p = 0.002$) of the WOTA 2. For the total score, post hoc tests revealed significant increases from baseline to post-test (a median absolute increase of 14.8%) ($Z = -2.36$, $p = 0.018$) and from baseline to follow-up (median absolute increase of 16%) ($Z = -2.37$, $p = 0.018$). Similar significant results were seen for the Wilcoxon post-hoc tests for the MA and SBM subdimensions. Individual changes for the total score are graphically shown in Figure 2. The minimum absolute improvement for all children was 9.9%. The largest improvement was seen in the subdimension SBM, showing a median absolute increase of 16.7%, compared to a 12.8% increase for MA. Effect sizes were moderate to large.

Table 2. Activity Level – Results

Activity level								
	Participant	Baseline	Post - test	Follow - up	% change (B –P)	% change (B – Fu)	ES (B–P)	ES (B–Fu)
WOTA 2 total (%)	1	69.1	88.9	88.9	28.6	28.6		
	2	44.4	55.6	58.0	25.0	30.6		
	3	48.2	63.0	66.7	30.8	38.5		
	4	76.5	90.1	90.1	17.7	17.7		
	5	0.0	26.3	26.3	> 100	> 100		
	6	33.3	58.0		74.1			
	7	79.0	88.9	91.4	12.5	15.6		
	median	48.2	63.0	77.8	28.6	29.6	0.66	0.71
	IQR	34.0	32.1	29.6	31.1	16.1		
WOTA 2 MA (%)	1	92.3	100.0	100.0	8.3	8.3		
	2	69.2	92.3	97.4	33.3	31.8		
	3	71.8	84.6	87.2	17.9	44.5		
	4	89.7	100.0	100.0	11.4	11.4		
	5	0.0	35.9	35.9	> 100	> 100		
	6	41.0	61.5		50.0			
	7	92.3	100.0	100.0	8.3	8.3		
	median	71.8	92.3	98.7	17.9	21.6	0.53	0.67
	IQR	35.9	26.9	10.3	31.8	32.2		
WOTA 2 SBM (%)	1	47.6	78.6	78.6	65.0	65.0		
	2	21.4	21.4	21.4	0.0	0.0		
	3	26.2	42.9	47.6	63.6	81.8		
	4	64.3	81.0	81.0	25.9	25.9		
	5	0.0	16.7	16.7	> 100	> 100		
	6	26.2	54.8		109.1			
	7	66.7	78.6	83.3	17.9	25.0		
	median	26.2	54.8	63.1	63.6	45.5	0.62	0.63
	IQR	32.1	46.4	52.4	65.2	52.4		

Note: % change (B–P) = Δ (Post-test - Baseline) / Baseline; % change (B–Fu) = Δ (Follow-up - Baseline) / Baseline
WOTA 2: Water Orientation Test Alyn 2; MA: Mental Adjustment subdimension; SBM: Skills, Balance & Movement subdimension; B: Baseline; P: Post-test; Fu: Follow-up; ES: Effect Size; IQR: Inter Quartile Range

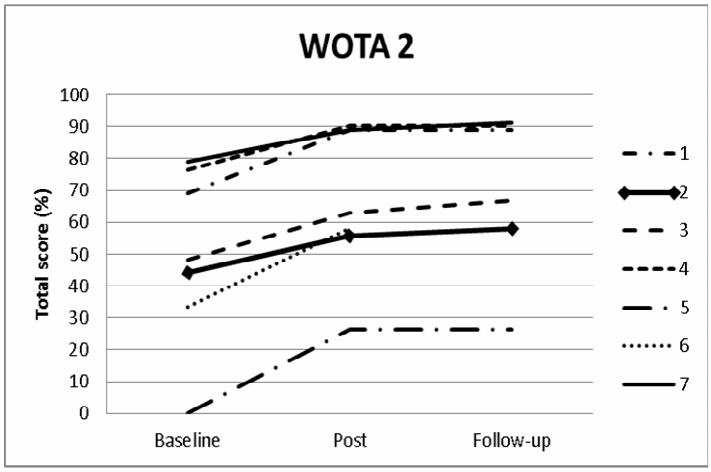

Figure 2. Total scores (%) for the Water Orientation Test Alyn 2 (WOTA 2) for all participants at baseline, post-test and follow-up. Scores increased after the 6-week swimming period and were maintained after a 3-week follow-up period.

Note: Participant number 6 only completed the baseline and post-test

The GMFM-88 results (Table 3) improved significantly for dimension D (standing) ($\chi 2 = 7.00$, $p = 0.03$). Post hoc test showed a significant median absolute improvement of 2.6% at post-test ($Z = -2.04$, $p = 0.04$). Individual results are shown in Figure 3. The subscore for dimension E of the GMFM-88 ($\chi 2 = 5.20$, $p = 0.07$) increased with a median of 2.8% post-intervention. Two children did not show any improvements in either dimension. The GMFM-88 total score ($\chi 2 = 5.15$, $p = 0.08$) increased with a median of 1.6% post-intervention, while three children showed no improvements larger than 1%.

Table 3. Activity Level – Results (continued)

Activity level								
	Participant	Baseline	Post - test	Follow - up	% change (B – P)	% change (B – Fu)	ES (B – P)	ES (B–Fu)
GMFM, Total	1	99.2	99.2	99.7	0.0	0.5		
	2	89.9	94.7	94.6	5.4	5.2		
	3	87.1	88.6	89.6	1.8	2.9		
	4	93.7	93.7	93.0	-0.1	-0.8		
	5	60.8	65.8	68.6	8.3	12.9		
	6	73.4	80.6		9.7			
	7	97.9	98.7	98.9	0.8	1.0		
	median	89.9	93.7	93.8	1.8	2.0	0.21	0.26
	IQR	15.6	12.1	11.7	6.4	4.0		
GMFM, dimension D	1	97.4	97.4	100.0	0.0	2.6		
	2	76.9	89.7	89.7	16.7	16.7		
	3	87.2	87.2	92.3	0.0	5.9		
	4	84.6	87.2	79.5	3.0	-6.1		
	5	35.9	46.2	53.8	28.6	50.0		
	6	61.5	74.4		20.8			
	7	92.3	94.9	97.4	2.8	5.6		
	median	84.6	87.2	91.0	3.0	5.7	0.30	0.39
	IQR	20.5	11.5	17.9	17.4	10.6		
GMFM, dimension E	1	98.6	98.6	98.6	0.0	0.0		
	2	80.6	87.5	84.7	8.6	5.2		
	3	83.3	86.1	83.3	3.3	0.0		
	4	88.9	91.7	90.3	3.1	1.6		
	5	23.6	20.8	20.8	-11.8	-11.8		
	6	37.5	55.6		48.1			
	7	97.2	98.6	97.2	1.4	0.0		
	median	83.3	87.5	87.5	3.1	0.0	0.14	0.10
	IQR	34.0	24.3	24.3	5.3	1.2		
10 MWT (m/s)	1	1.1	1.1	1.3	0.4	18.0		
	2	0.9	1.0	1.1	17.5	23.1		
	3	0.9	1.1	1.1	19.9	27.4		
	4	1.4	1.2	1.3	-12.9	-6.7		
	5	0.3	0.4	0.4	23.7	36.5		
	6	0.6	0.5		-17.9			
	7	1.0	1.1	1.1	8.1	12.0		
	median	0.9	1.1	1.1	8.1	20.53		
	IQR	0.3	0.4	0.4	25.0	12.8		

Note: % change (B–P) = Δ (Post-test - Baseline) / Baseline; % change (B–Fu) = Δ (Follow-up - Baseline) / Baseline. GMFM: Gross Motor Function Measurement; 10-MWT: 10 meter walk test; B: Baseline; P: Post-test; Fu: Follow-up; ES: Effect Size; IQR: Inter Quartile Range

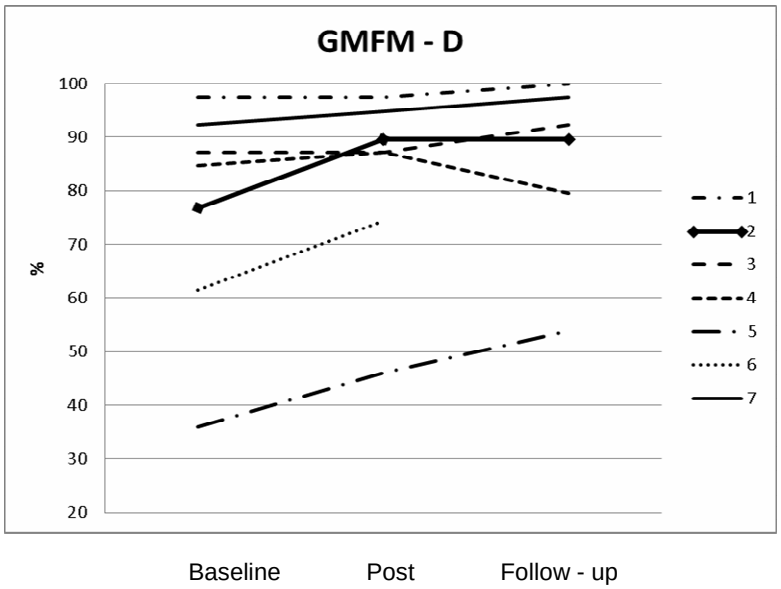

Figure 3. Percentage scores for dimension D (standing) for the Gross Motor Function Measurement-88 (GMFM-88) for all participants at baseline, post-test and follow-up. Scores increased for all but 2 children.
Note: Participant number 6 only completed the baseline and post-test

No other significant results were observed (Table 3, 4, 5), but several trends were seen at activity level and for QOL. The 10-m walking speed (Table 3) increased with median 0.07 m/s after six weeks of swimming, and increased further after three weeks of follow-up (0.12 m/s) ($\chi 2 = 4.69$, $p = 0.10$). Two of the seven children did show a decrease.

The time necessary to perform all tasks of the Jebsen-Taylor hand function test (Table 4) decreased to 7.9 and 6.1 seconds after the 6-week intervention, for the dominant ($\chi 2 = 3.63$, $p = 0.16$), and non-dominant hand ($\chi 2 = 3.63$, $p = 0.16$), respectively. One child showed no improvements in either hand. The results for handgrip strength (median increase of 0.5 kg for the dominant hand and 0.0 kg for the non-dominant hand) showed no trends (dominant $\chi 2 = 1.40$, $p = 0.50$, non-dominant $\chi 2 = 1.52$, $p = 0.47$).

Quality of life (Table 5) measured using the CPQOL – parent showed improvements for the subdimensions 'Functioning' ($\chi 2 = 0.54$, $p = 0.76$), 'Participation and physical health' ($\chi 2 = 0.07$, $p = 0.96$), 'Access' ($\chi 2 = 3.63$, $p = 0.16$), 'Pain and impact of disability' ($\chi 2 = 5.85$, $p = 0.05$) and 'Family health' ($\chi 2 = 1.91$, $p = 0.39$). For the subdimension 'Pain and impact of disability' five of the six children showed a decrease in score, implying an improvement. The LH – parent questionnaire did not show any changes ($\chi 2 = 0.00$, $p = 1.00$).

DISCUSSION

This study explored the effect of a swimming intervention on different problems at various levels of the ICF model apparent in children with CP. Our study demonstrated that a 6-week aquatic program improves the adjustment and function in water, and might improve gross motor function. Over the 6-week period all activity level measures showed trends towards improvement. Nearly all results remained at follow-up. In addition, improvements for five out of seven subdimensions of CPQOL – parent were observed.

The increase in water adjustment skills is in line with previous findings [12, 17, 21, 22, 24]. To the best of our knowledge two studies used the WOTA 2 as it was implemented here [12, 24].

The baseline value assessed in our study (WOTA 2, median value 48%, mean value 50%) was higher than that of Jorgić et al [24] (mean 37%) and Dimitrijević et al [12] (mean 27.8%). This might be due to the sample of Dimitrijević et al [12] including seven children classified with level IV and V on the GMFCS and the slightly younger age group in the sample of Jorgić et al [24]. The subdimension SBM shows lower baseline levels than the MA, as was the case in Jorgić et al [24] and Dimitrijević et al [12]. An average increase of 25% and 31% was found in these studies after a 6-week intervention, respectively. This is slightly higher than the median/mean increase of 15%/17% in the present study, which might be explained by the lower baseline values in the samples of the previous studies. The maintenance of the result at follow-up was also reported by Dimitrijević et al [12]. In both studies [12, 24], higher increases were seen in the subdimension SBM compared to MA, similar to present results. This larger increase in the SBM might be due to the lower baseline levels for SBM.

Table 4. Upper limb (Function and Activity Level) – Results

Upperlimb						
	Participant	Baseline	Post-test	Follow-up	% change (B–P)	% change (B–Fu)
Hand grip strength (kg) Dominant	1	26.3	24.3	23.7	-7.6	-10.1
	2	9.0	9.3	7.0	3.7	-22.2
	3	7.3	10.0	12.7	36.4	72.7
	4	20.0	20.7	19.3	3.3	-3.3
	5	3.5	4.0	4.7	14.3	33.3
	6	12.7	12.3		-2.6	
	7	13.0	18.0	17.0	38.5	30.8
	median	12.7	12.3	14.8	3.7	13.7
	IQR	8.3	9.7	8.5	25.0	41.1
Hand grip strength (kg) Non-Dominant	1	8.0	8.0	8.7	0.0	8.3
	2	6.0	8.3	5.5	38.9	-8.3
	3	8.3	11.3	12.0	36.0	44.0
	4	6.7	7.3	6.3	10.0	-5.0
	5	3.0	3.0	2.7	0.0	-11.1
	6	10.7	8.0		-25.0	
	7	18.7	18.0	15.0	-3.6	-19.6
	median	8.0	8.0	7.5	0.0	-6.7
	IQR	3.2	2.2	4.4	24.8	15.4
Jebsen Taylor (s) Dominant	1	38.3	37.0	33.6	3.2	12.2
	2	64.8	75.5	58.1	-16.4	10.3
	3	68.8	59.7	69.0	13.2	-0.2
	4	44.4	42.2	39.4	5.1	11.4
	5	366.7	354.4	339.8	3.4	7.4
	6	104.1	74.3		28.6	
	7	70.3	62.4	72.6	11.2	-3.3
	median	68.8	62.4	63.3	5.1	8.8
	IQR	32.6	23.9	24.7	8.9	9.4
Jebsen Taylor (s) Non-Dominant	1	117.6	98.4	87.4	16.3	25.6
	2	76.9	76.1	72.3	1.0	6.0
	3	80.8	74.8	79.2	7.5	2.1
	4	337.8	121.8	158.5	63.9	53.1
	5	399.7	375.0	354.6	6.2	11.3
	6	234.8	319.3		-36.0	
	7	72.2	68.4	73.0	5.3	-1.1
	median	117.6	98.4	83.3	6.2	8.6
	IQR	207.4	145.1	162.8	8.7	19.0

Note: % change (B–P) = Δ (Post-test - Baseline) / Baseline; % change (B–Fu) = Δ (Follow-up - Baseline) / Baseline.
B: Baseline; P: Post-test; Fu: Follow-up; IQR: Inter Quartile Range

The GMFM-88 improved in four out of seven children for the total score. Three children (participant numbers 1, 4, 7) with the highest baseline values (GMFCS level I) did not improve, which might be due to a ceiling effect. The children with the largest improvements for the total score had the lowest baseline levels (GMFCS level III (participant numbers 5 and 6)). The same trend was seen for dimensions D and E. No comparison to others could be made, as no previous studies provided individual results.

For the GMFM-88 total score, the present sample had a baseline level of 90% and increased with a median of 1.6%. Previous studies using the GMFM showed slightly different results. The non-randomised controlled trial (n = 27) by Dimitrijević et al [12] showed a significant improvement in 5- to 14-year-old children with CP (GMFCS level I to V) after a 6-week swimming intervention for the total score (4.4%) (explained by the lower baseline level of 73.5%). Jorgić et al [24] showed a similar improvement in total score (1.7%) and dimension E (5%) of the GMFM-88 in seven children (aged 7–11 years) with GMFCS I to III (baseline levels 90% (total) and 75% (SBM)).The case series design by Thorpe et al [36] found a significant effect (7%) but only in dimension E (walking, running and jumping) after a 10-week intervention in children aged 7–13 years.

Table 5. Quality of Life – Results

Quality of Life (*n* = 6)						
		Baseline	Post-test	Follow-up	% change (B–P)	% change (B–Fu)
CPQOL –Parent (%)						
Social well-being						
	median	76.6	76.6	75.5	-5.9	-3.7
	IQR	10.2	12.5	8.4	4.3	5.4
Functioning						
	median	68.8	69.5	73.4	1.2	4.6
	IQR	4.4	6.9	4.2	8.3	11.1
Participation and physical health						
	median	67.0	66.0	69.3	3.7	4.2
	IQR	5.7	4.8	12.8	15.3	21.0
Emotional well-being						
	median	76.0	76.0	72.7	-1.2	-1.7
	IQR	2.1	16.1	11.0	8.9	12.1
Access						
	median	58.2	66.8	53.8	20.9	-3.1
	IQR	16.7	9.0	21.1	30.0	14.9
Pain and impact of disability						
	median	36.7	18.8	28.9	19.4	14.9
	IQR	16.8	23.8	11.3	27.2	23.8
Family health						
	median	71.9	73.4	76.6	4.3	7.3
	IQR	7.0	10.2	10.2	12.4	9.7
LH – parent (/10)						
Total score						
	median	7.4	6.9	7.2	2.0	2.2
	IQR	2.2	1.8	1.8	14.1	12.6

Note: % change (B–P) = Δ (Post-test - Baseline) / Baseline; % change (B–Fu) = Δ (Follow-up - Baseline) / Baseline
CPQOL-Parent: CP Quality of Life Questionnaire Parent version; LH-parent: Assessment of Life Habits – parent version; B: Baseline; P: Post-test; Fu: Follow-up; IQR: Inter Quartile Range

This effect was still present after 11 weeks of follow-up. Another case series design [2] including only adolescents, found a significant improvement of 3% for dimension E, for the participating adolescents classified level III and IV on the GMFCS (low baseline level of 24%) compared to no increase for the adolescents with level I and II (high baseline level of 87%). A randomised controlled trial [10] showed non-significant improvements for both the dimensions D (2%) and E (6%), after a 10-week swimming program (baseline levels respectively 75% and 59%).Getz et al [18] reported no significant differences between an aquatic and a land-based training group after four months in children aged 3–6 years with spastic diplegia. The aquatics group did improve by 3% for the combined dimensions D and E (baseline level 31%). The various results in previous studies might be attributed to differences in population (e.g. age groups, GMFCS levels, and therefore baseline levels) or in the aquatic intervention programs. Ballaz et al [2], Chrysagis et al [10], Dimitrijević et al [12], Getz et al [18], and Jorgić et al [24] used a program focussing on swimming skills in contrast to Thorpe et al [36], who focused on exercises for the trunk and lower extremities and used specific strengthening exercises in the water rather than swimming. Our study focused on swimming skills but included exercises such as push offs from the wall and jumping. In addition the session frequency varied. Thorpe et al [36] had children swimming three times a week, compared to twice a week in the other studies [2, 10, 12, 18, 24].

Only one study [18] used the 10-MWT and showed significant improvements after both an adapted aquatics program (0.11 m/s) and a land-based program (0.29 m/s), in 3–6-year-old children with spastic

diplegia. The relative improvements were higher (18% for the aquatics group) for the study by Getz et al [18] compared to the present study (8%), as the baseline values were lower (0.6 m/s) compared to the present study (median 0.9 m/s).

The fact that our aquatic program focused on swimming skills with the emphasis on the use of upper limbs could have contributed to the improvement in time for the Jebsen-Taylor test for both hands (median 5% and 6% of the baseline value) that was maintained at follow-up. No comparison can be made with previous studies.

The decrease in the parent-reported subdimension 'Pain and impact of disability' of the CPQOL – parent requires further investigation as it is an important aspect of rehabilitation for CP, especially in relation to transition to adulthood. No differences compared to the other participants were seen in the results of the child (with spastic diplegia) who had a botulinum toxin type A infiltration in m. gastrocnemius three months before the start of the intervention.

STUDY LIMITATIONS

This study used a case series design involving seven children with CP, and no control group: therefore, generalization is difficult. A second potential limitation of the study is the representativeness of the sample for the CP population in general. Firstly, the GMFCS levels of the children in the present study ranged only from level I to III, thus not reflecting the entire population of CP. A similar tendency was observed in the studies by Getz et al [17], Getz et al [18], and Jorgić et al [24]. Within the present study group, four out of seven participants were classified as level I according to the GMFCS and a median of 90% was observed at baseline for the GMFM-88. Additionally, most participants entering the trial were keen to take part in the aquatic intervention program with their personal ambition to learn to swim. However, it is not to be expected that in general children with CP would be as keen to swim or exercise as the children in the current study. Although the recruitment of participants was based on the diagnoses of CP and not on fitness level, we believe that research projects involving physical activity will generally attract people who are interested in exercise. This tendency toward high interest in this kind of physical activity was also reported in the children from the study by Dorval et al [13]. The third limitation of the study is the absence of blinded assessors.

Another limitation is the absence of the participation level and the contextual factors of the ICF model in the outcome measures, along with the limited amount of measurements on body function level, where only hand grip strength was measured. Finally, two out of seven children were diagnosed with autism spectrum disorder. It was difficult to encourage them to perform the unimanual speed test as quickly as possible and without paying attention to the way the objects were placed.

Important to note is the positive response of both parents and children during and after the intervention. No drop-out occurred during the intervention and no treatment complications were reported during or after.

Parental concerns included lack of time and fatigue hindering the child in school work and family activities. This might point towards the importance of the child's activity and therapy program in general and the inclusion of siblings and parents in the swimming program. Despite the time problems, high compliance was reached: the median participation to the program was 100% in present study. Moreover, six out of seven children who participated were still integrated in a swimming club or program after one year.

Future research is needed by setting up a Randomised Controlled Trial (RCT) to compare the addition of an aquatic program to the usual care of children with CP including a larger sample size, in combination with the investigation of different aspects influencing QOL (e.g. pain and fatigue). However, the difficulty in recruiting sufficient participants should not be forgotten. Low numbers of participants is an issue in several previous studies on aquatics and children with CP. The present study recruited by contacting 14 paediatric physical therapists, a rehabilitation centre and a special school. Thorpe et al [36] recruited through local clinics and therapists and gathered a sample of only seven children. Dorval et al [13] partly used the same recruitment method as in the present study: through a paediatric rehabilitation centre, resulting in the enrolment of 20 adolescents, only 12 of whom completed the follow-up. When recruitment was performed through schools, however, and when implementing the aquatic program in the school program, a higher number of participants were gathered: Hutzler et al [21, 22] gathered 46 children in kindergartens that implemented swimming in their educational program. Getz et al [16, 17] implemented the same recruitment method and gathered respectively 22 and 17 participants.

CONCLUSION AND PRACTICAL APPLICATION

The present study showed improvements in adjustment and functioning in water after a 6-week swimming intervention. The improvements were still present after a 3-week follow-up period. Different positive trends were observed for gross motor function, walking capacity, unimanual performance and several subdimensions of QOL.

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